

AIAA GNC Conference Session: 139-GNC-49

Paper: AIAA-2008-7143
“Analysis of the Aircraft to
Aircraft Conflict Properties
in the National Airspace
System”

Presented to: AIAA GNC, Honolulu, Hawaii

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Federal Aviation
Administration



Presentation Outline

- **Motivation – why**
- **Background – previous work**
- **Model to Predict Conflict Events**
 - Description
 - Calibration through DOE
 - Validation
- **Data Collection**
- **Results**
- **Closing Remarks**



Motivation of the Study

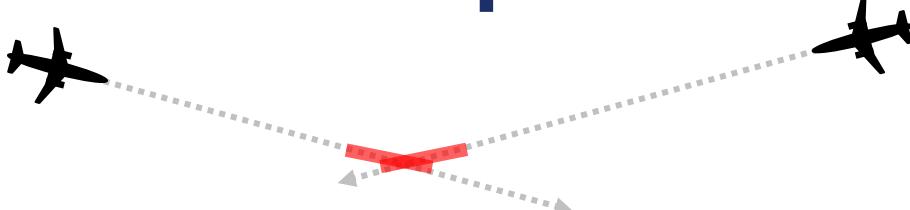
- **Primary function of Air Traffic Control (ATC)**
 - Safely separate aircraft to prevent collisions
 - Organize/expedite flow of traffic
 - Provide info to pilots when possible
- **Joint Planning Development Office (JPDO)**
 - Forecasts 1.4 to 3 times traffic increase by 2025
 - Next Generation (NextGen) Program
 - NextGen Separation Management Project
 - Improve separation management automation support
 - Simulations - human in the loop & fast-time
 - Study algorithms
 - Develop automation requirements for ERAM
 - Evaluate prototype modules in ERAM to achieve above

Background on Study

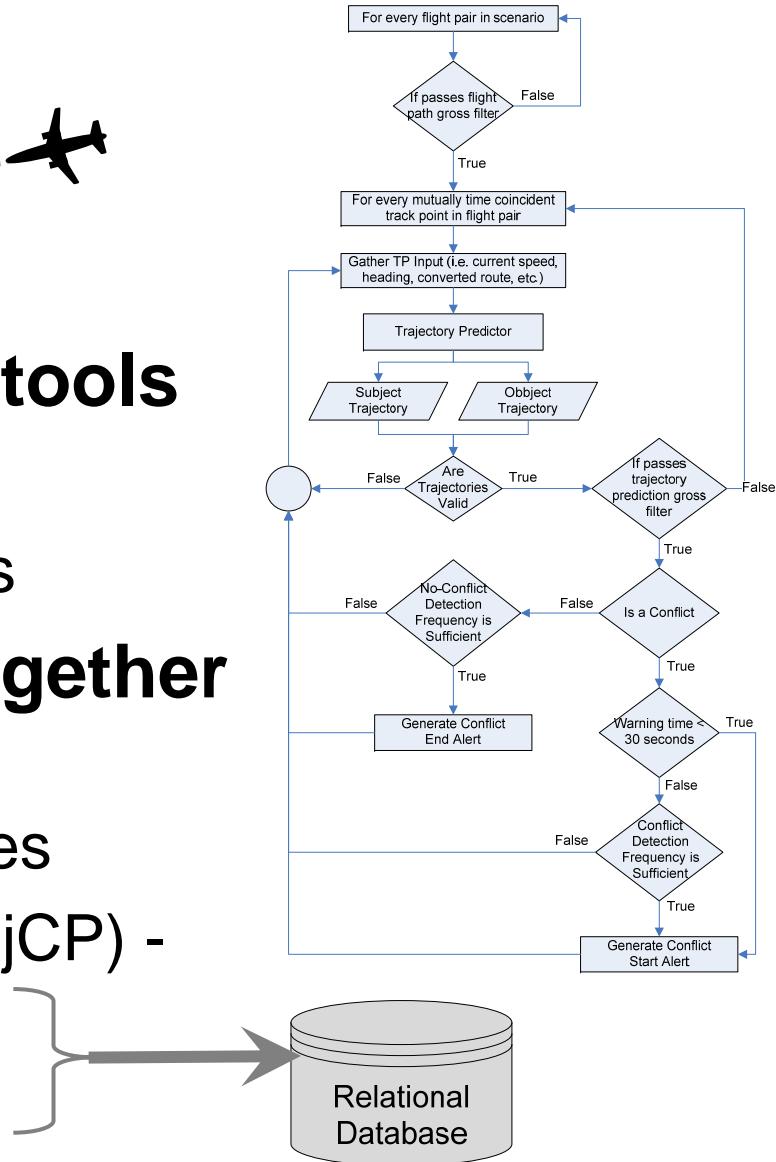
- **Conflict Probe Automation**
 - Predict aircraft-to-aircraft conflicts and recommend resolutions
 - To be used – MUST be accurate and timely
 - Sensitive to characteristics or properties of conflicts
 - Paper documents these conflict properties
 - Future work – error sensitivity and improvements
- **Review of Previous Studies**
 - United States: by NASA Ames, March 2001, NAS-wide
 - Europe: by Eurocontrol, June 2003, European airspace
 - Results
 - Both are several years old, especially NAS study
 - European above FL60 and NAS above FL180
 - European used RVSM; NAS study before RVSM
 - Both studies reported on largely different properties



Model Description



- **Non-operational software tools**
 - To predict conflicts
 - To estimate conflict properties
- **Two distinct tools work together**
 - Trajectory Predictor (TP) - predicts 4-D aircraft trajectories
 - Trajectory Conflict Probe (TrajCP) - uses TP trajectories and generates conflict predictions

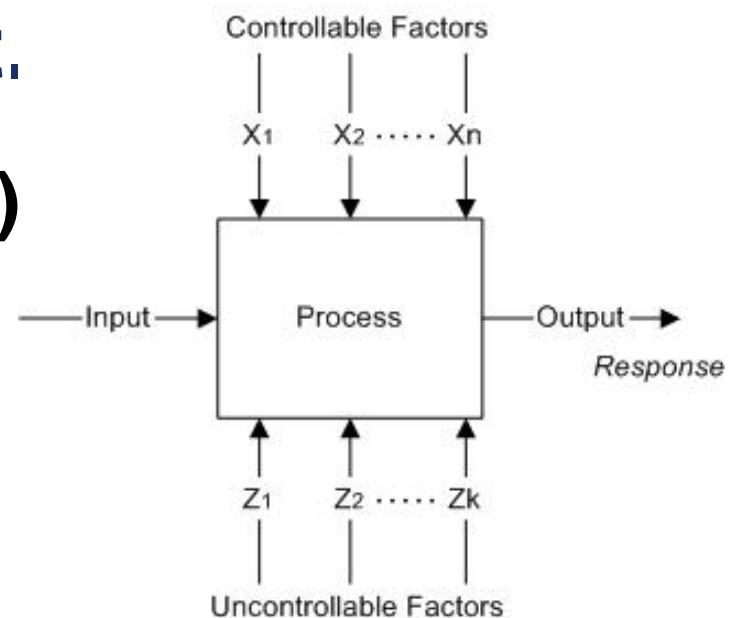


Model Calibration

- **TrajCP has many parameters**
- **Implemented statistical experiment (a.k.a. DOE)**
- **Dependent Variables (Response)**
 - Missed alert rate of TrajCP – R(MA)
 - False alert rate of TrajCP – R(FA)
 - Average warning time – WT
- **Independent Variables (Factors)**
 - Look-ahead time (LH) – [600 to 1200s]
 - Minimum detection time – [20 to 60s]
 - I of J for ADD – [60,90%] of [10,30]
 - I of J for DEL – [60,90%] of [10,30]

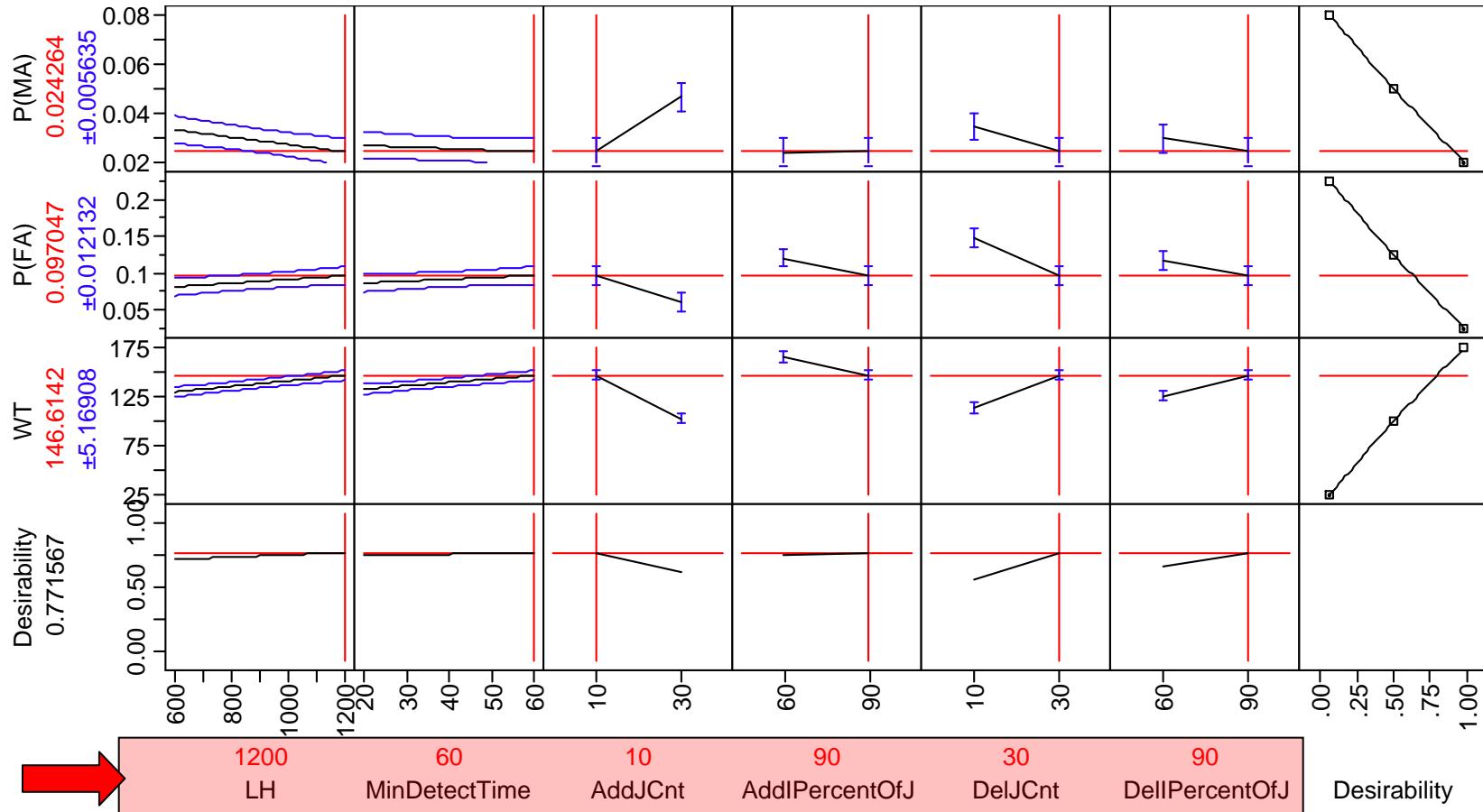
Model Calibration Cont.

- **Design of Experiment (DOE)**
 - Three response variables
 - Six factors
- **Implemented Fractional Factorial Experiment**
 - Factorial at two levels each: $2^6=64$ runs
 - Fractional: main & 2-factor interactions only – 32 runs
- **Excellent results**
 - R-squared > 98%
 - Residuals goodness of fit - Normally distributed

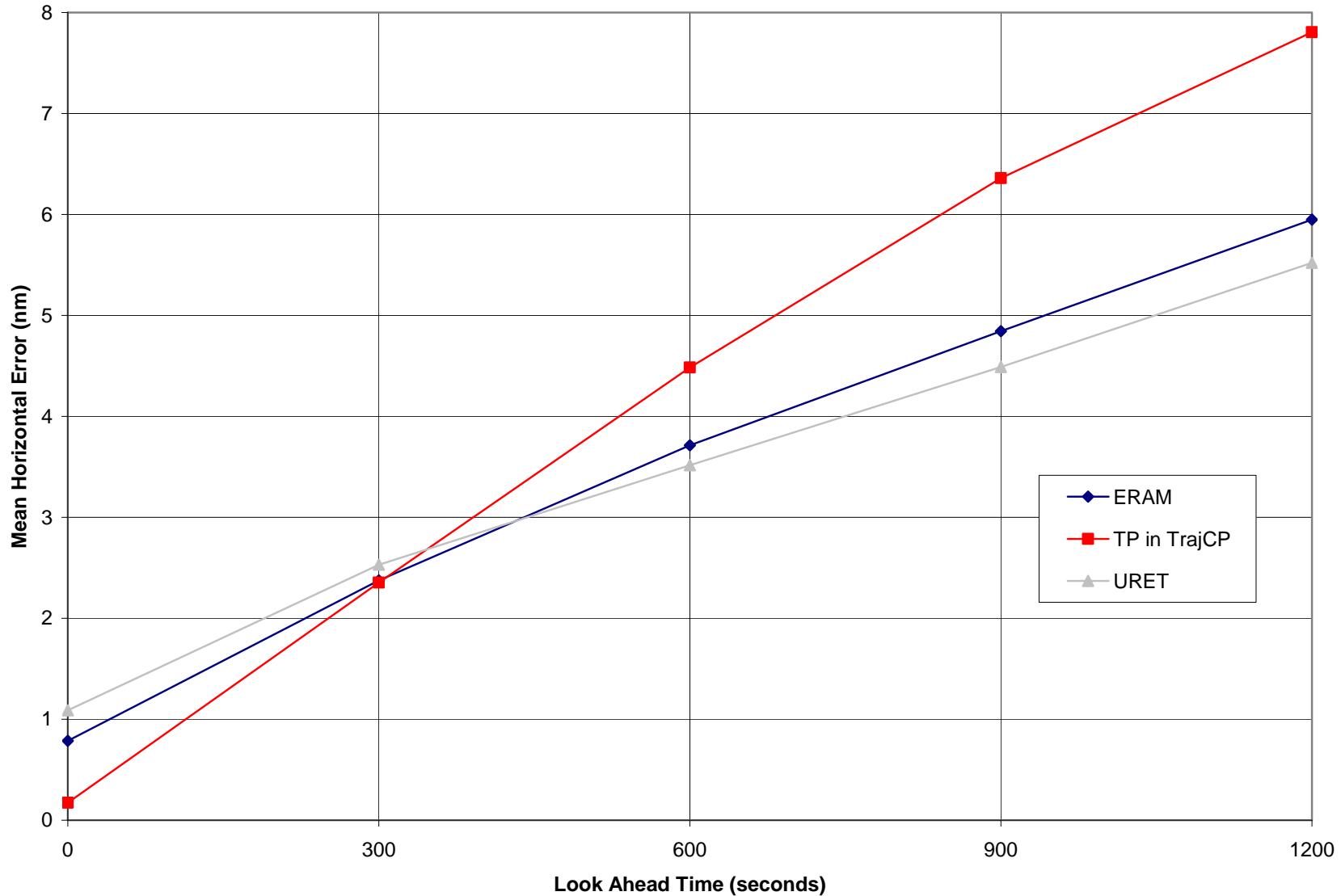


Model Calibration Continued

- From SAS JMP[©] software, best settings...



Model Validation – TP Performance



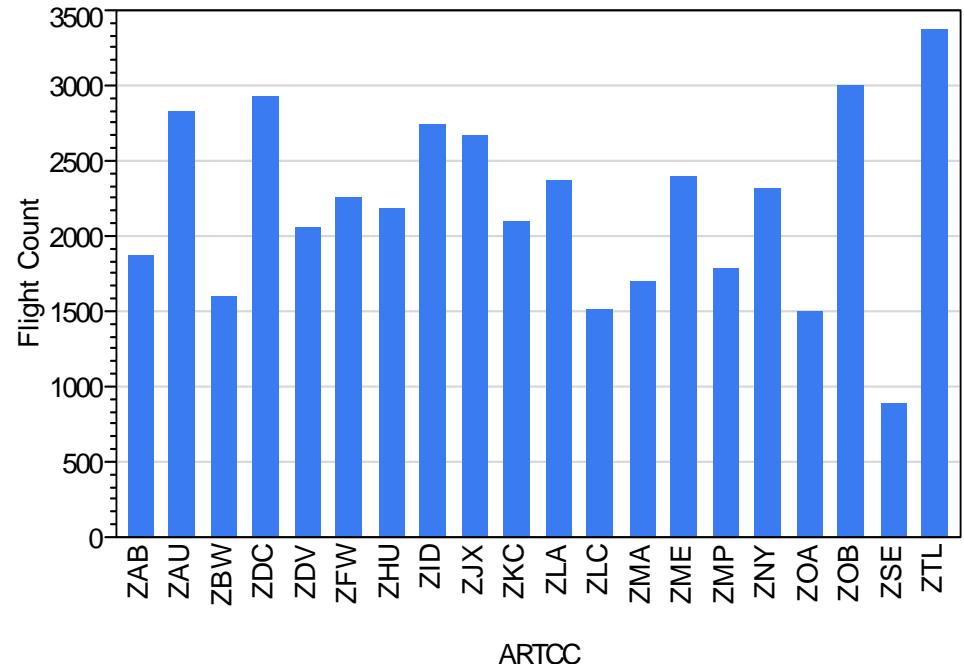
Model Validation – TrajCP Performance

- Using traffic data from ERAM formal tests based on ZDC data set

	URET	ERAM	TrajCP
False Alerts (FA)	88	108	26
Miss Alerts (MA)	8	4	6
Valid Alerts (VA)	234	218	231
Verified Conflicts	242	222	237
Verified Alerts	322	326	257
R(MA)	3.3%	1.8%	2.5%
R(FA)	27.3%	33.1%	10.1%
Avg Warning Time (WT)	0:03:46	0:03:42	0:02:25

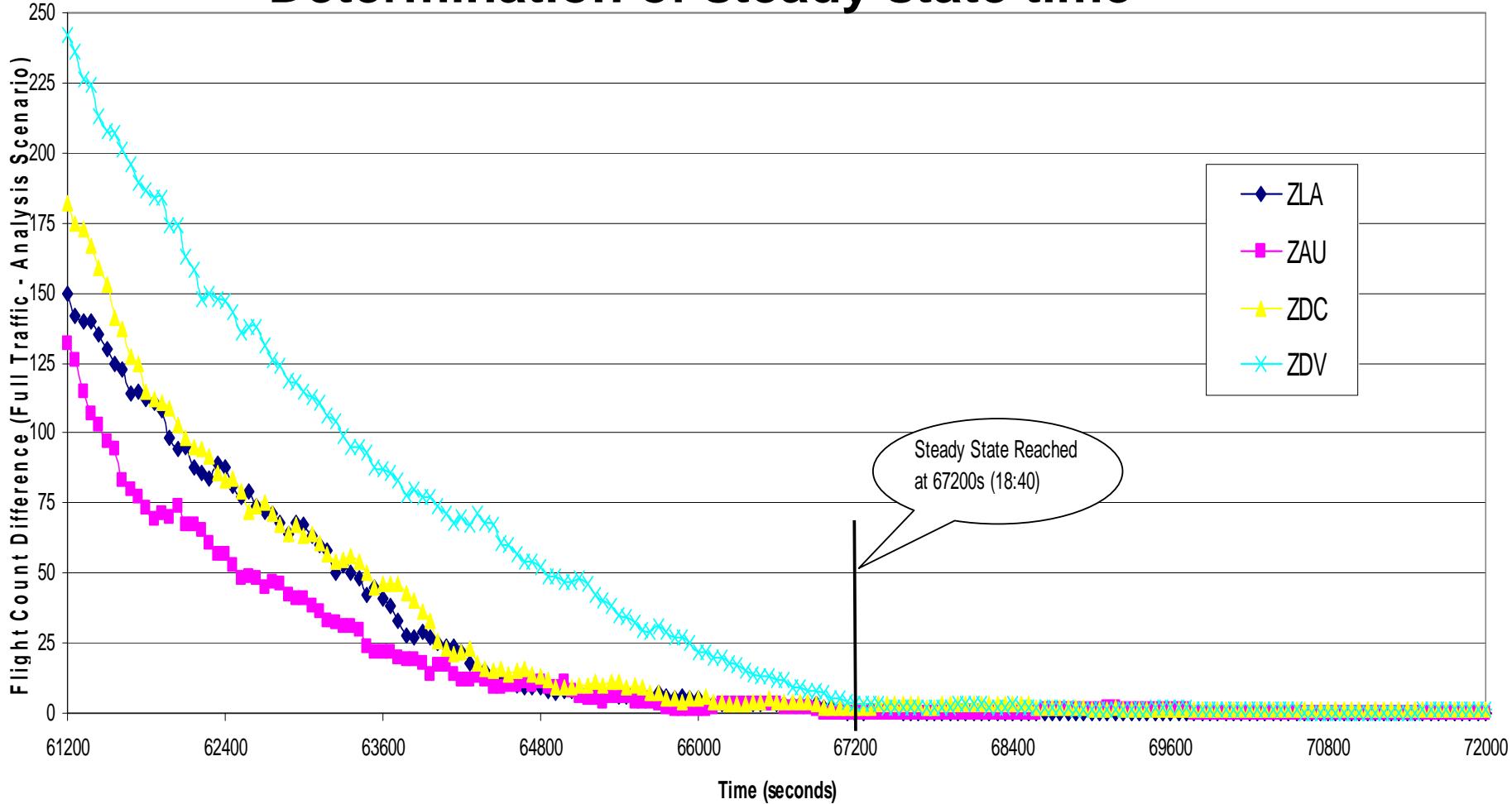
Data Collection

- **Data collection on April 3, 2008 1700-2359 UTC**
 - Almost 40K flights
 - CMS data
 - Flight plans
 - Interim altitude messages
 - Route messages
 - ARTCC adaptation
 - RUC weather
- **Originally 24 hours reduced to peak 7 hours**
- **Then reduced to 5.5 hours...**



Data Collection Continued

-- Determination of steady state time --

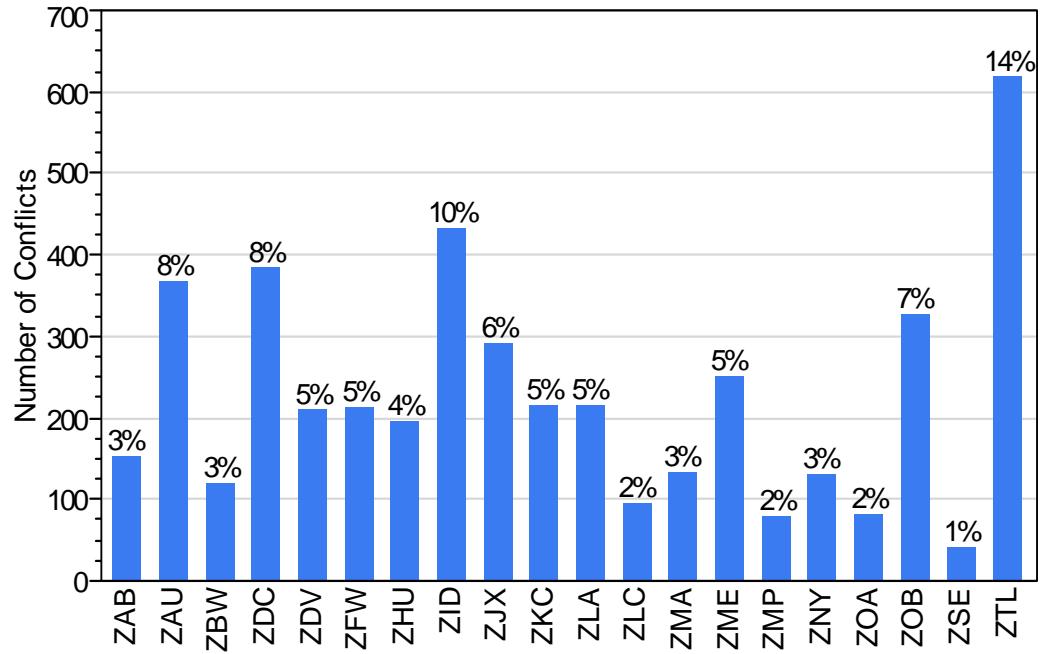


Results – Conflict Properties

Three Categories of Conflict Properties

1. **System properties** characterize the conflicts in context of airspace and air traffic where found
Example: Instantaneous conflict counts by ARTCC
2. **Event properties** characterize the individual conflict events state, geometry, either spatial or temporal
Examples: Encounter angle, minimum separations
3. **Interaction properties** characterize the relationships between two or more conflict events
Example: Degree of temporal overlap between conflicts

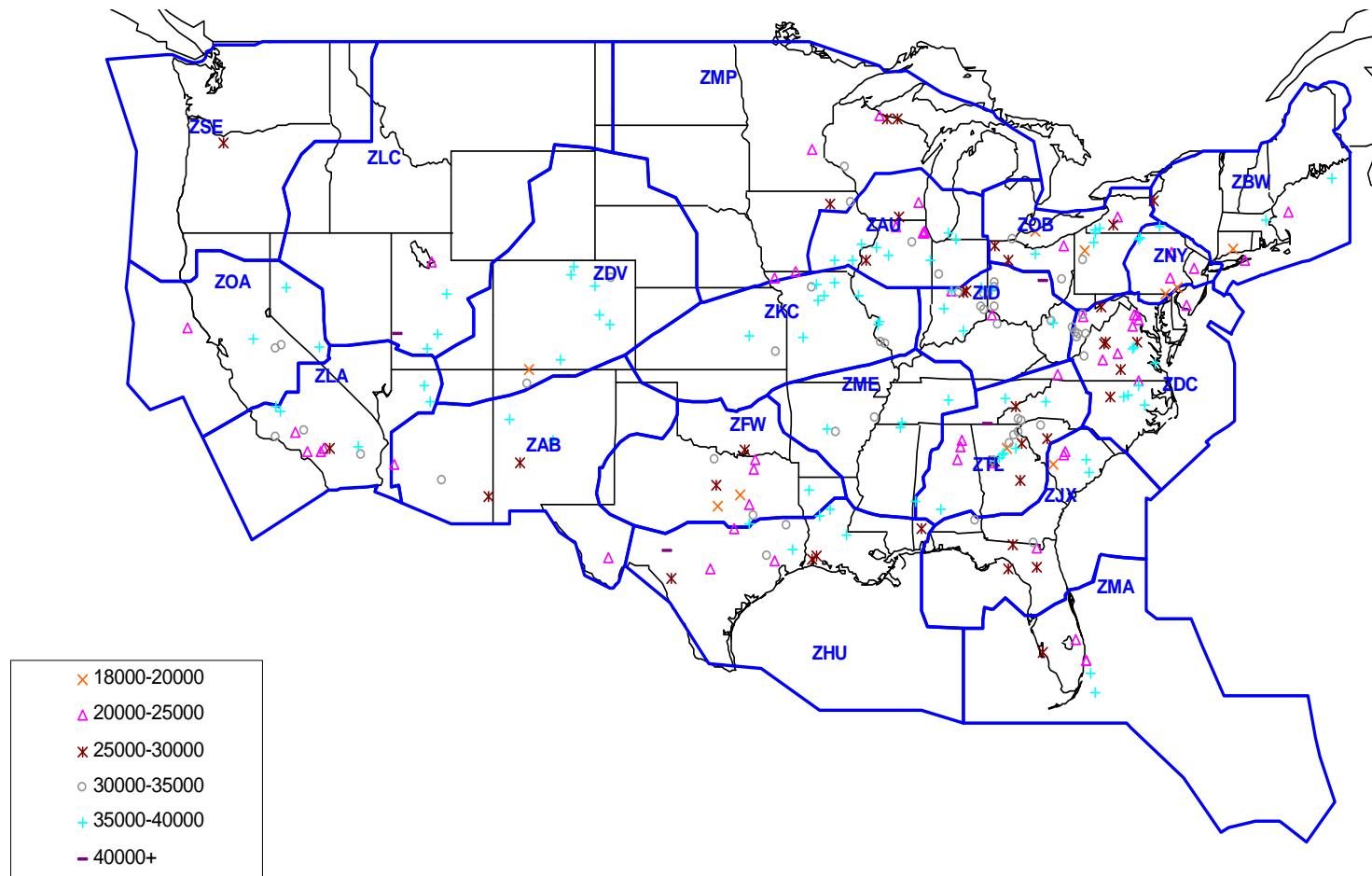
Results: System Conflict Properties



NAS Code : ARTCC					
ZAB	Albuquerque	ZAU	Chicago	ZBW	Boston
ZDC	Washington DC	ZDV	Denver	ZFW	Fort Worth
ZHU	Houston	ZID	Indianapolis	ZJX	Jacksonville
ZKC	Kansas City	ZLA	Los Angeles	ZLC	Salt Lake City
ZMA	Miami	ZME	Memphis	ZMP	Minneapolis
ZNY	New York	ZOA	Oakland	ZOB	Cleveland
ZSE	Seattle	ZTL	Atlantic		

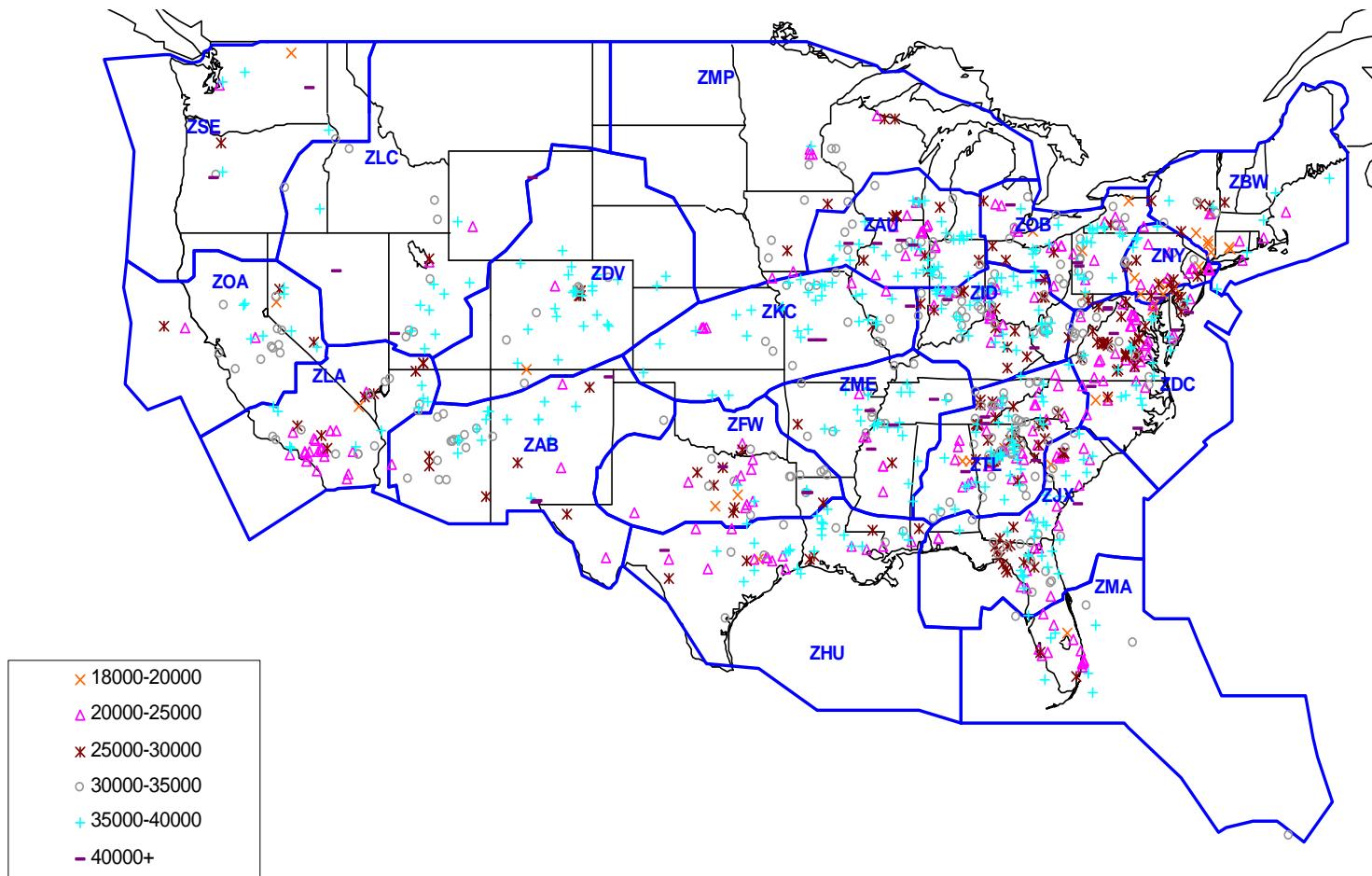
Horizontal View of Conflicts

Data Source: Hour 1 Collected on April-3-2008



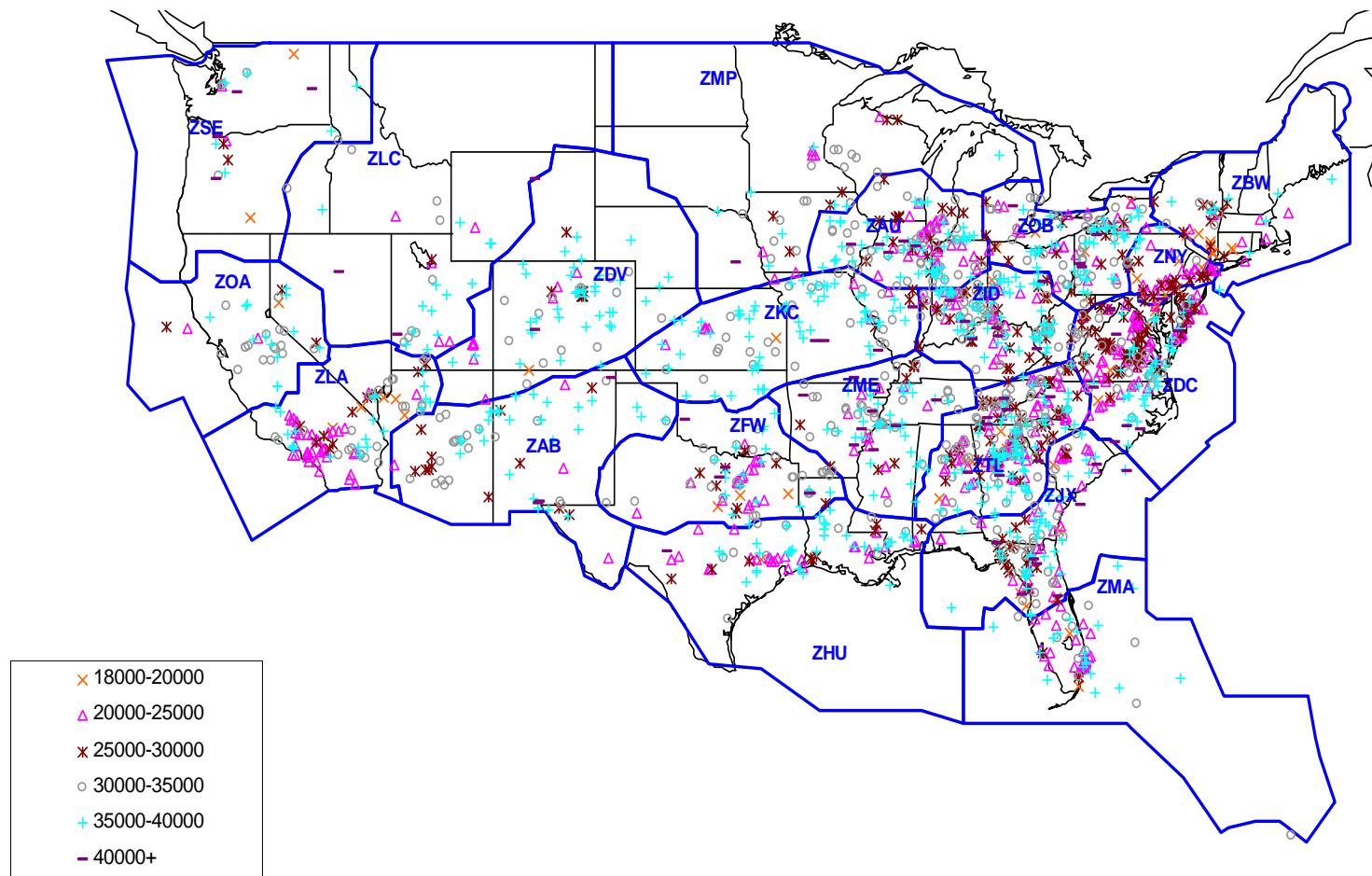
Horizontal View of Conflicts

Data Source: Hour 2 Collected on April-3-2008



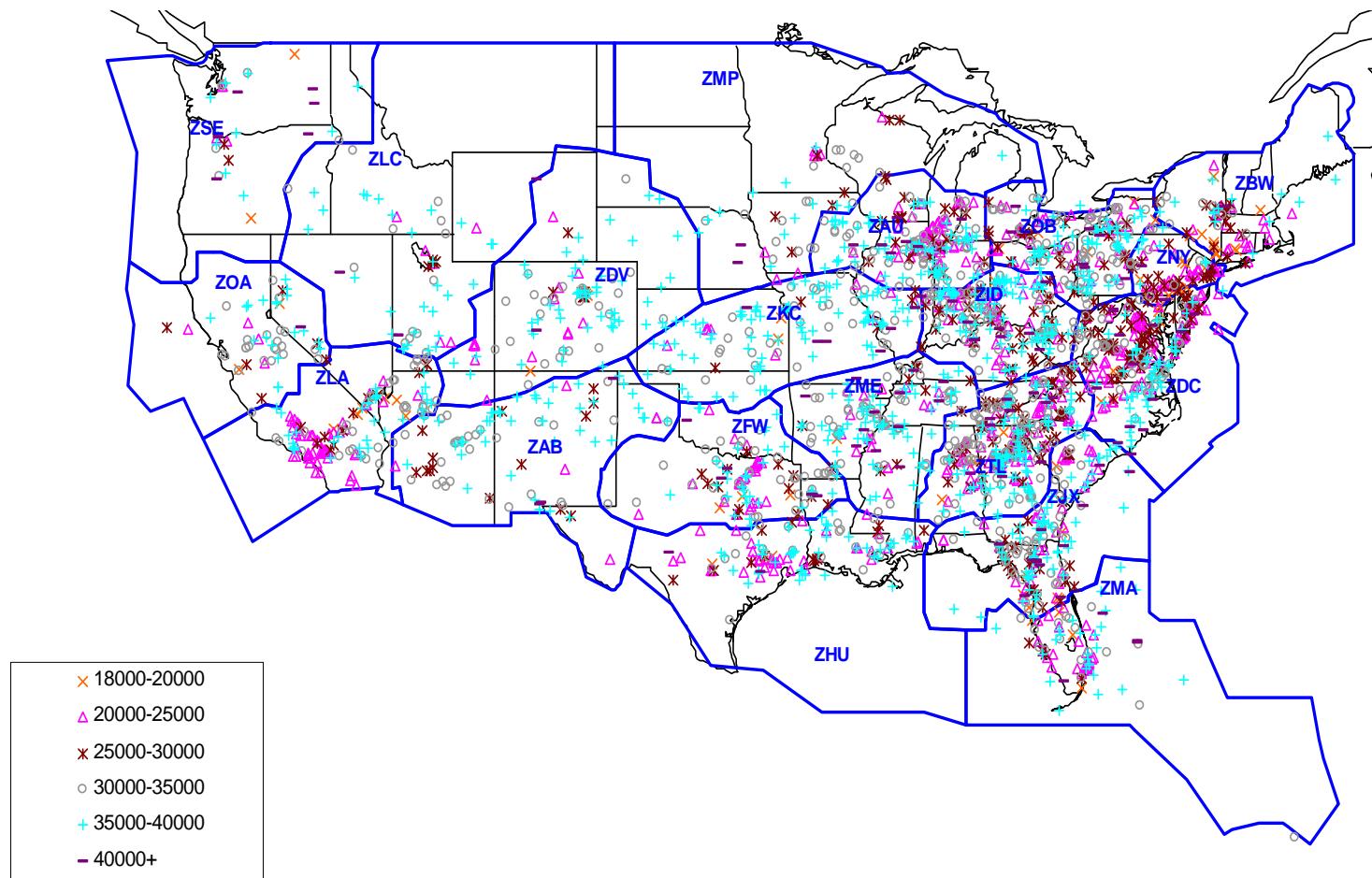
Horizontal View of Conflicts

Data Source: Hour 3 Collected on April-3-2008



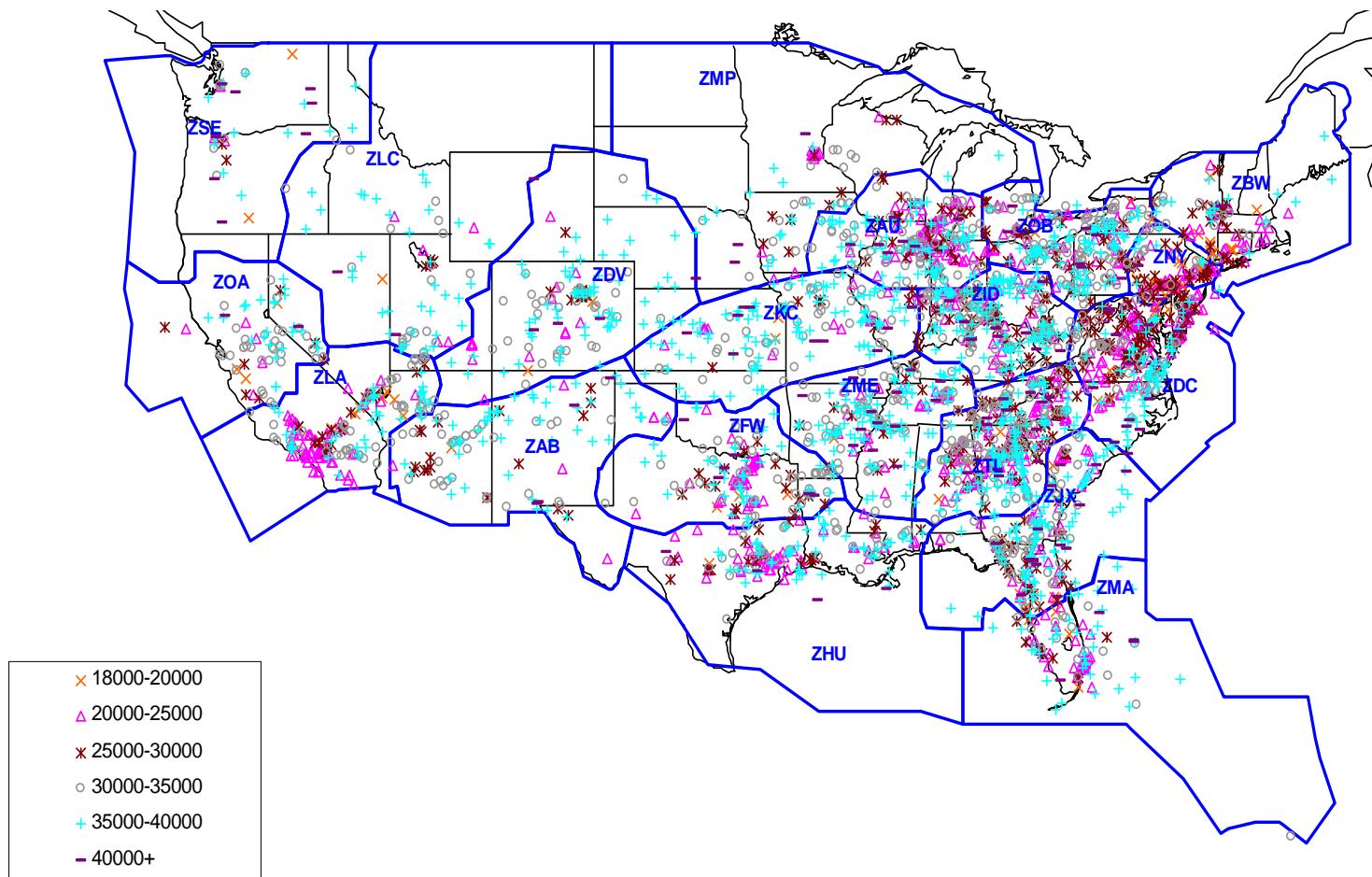
Horizontal View of Conflicts

Data Source: Hour 4 Collected on April-3-2008



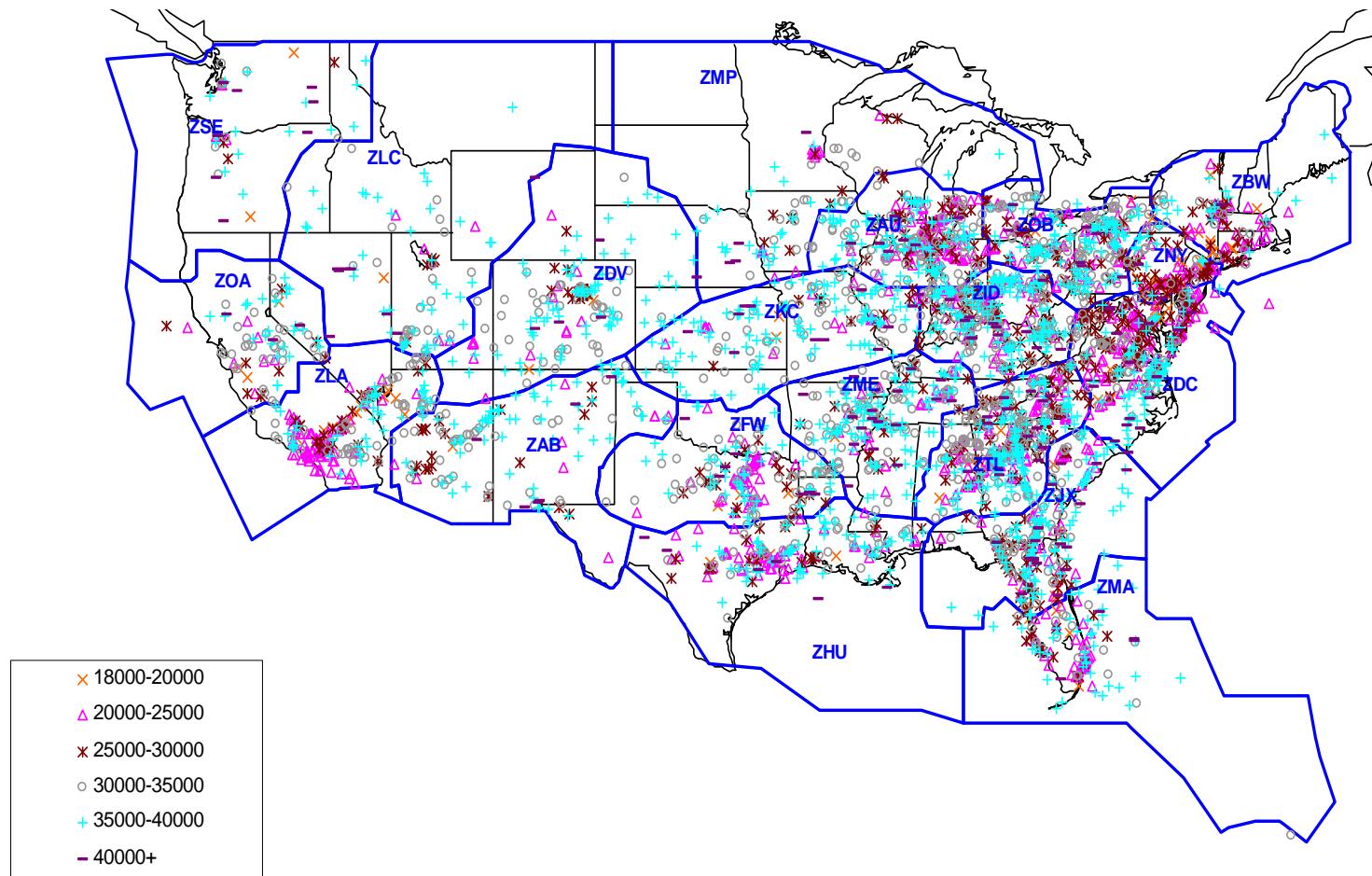
Horizontal View of Conflicts

Data Source: Hour 5 Collected on April-3-2008

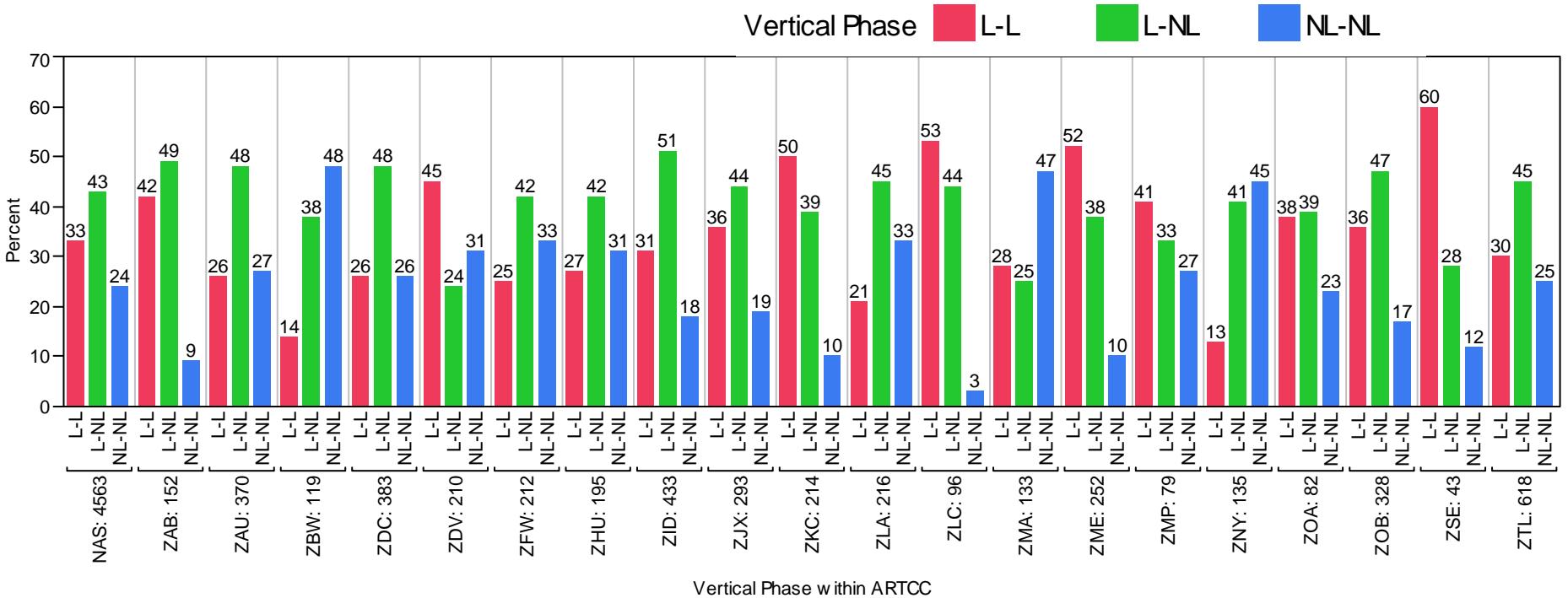


Horizontal View of Conflicts

Data Source: Hour 6 Collected on April-3-2008

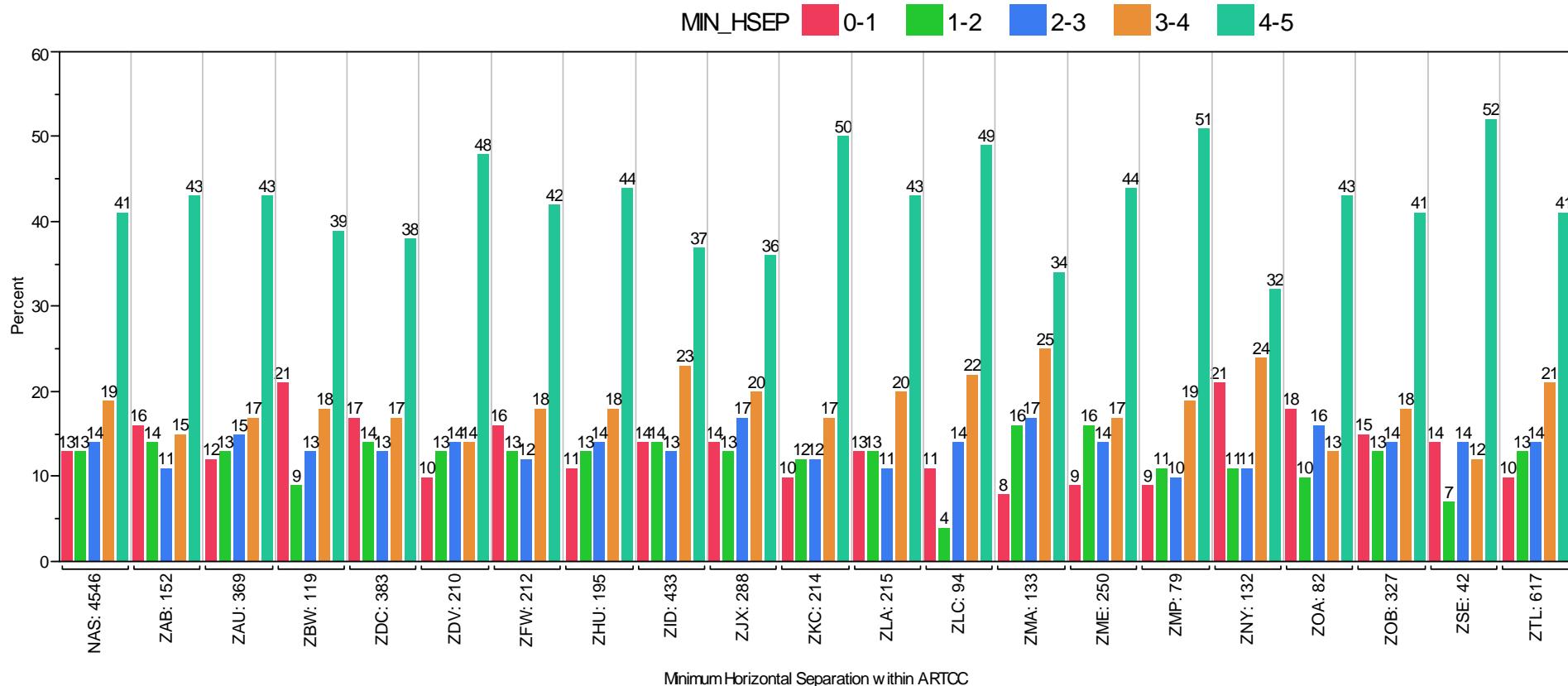


Results: Event Conflict Properties



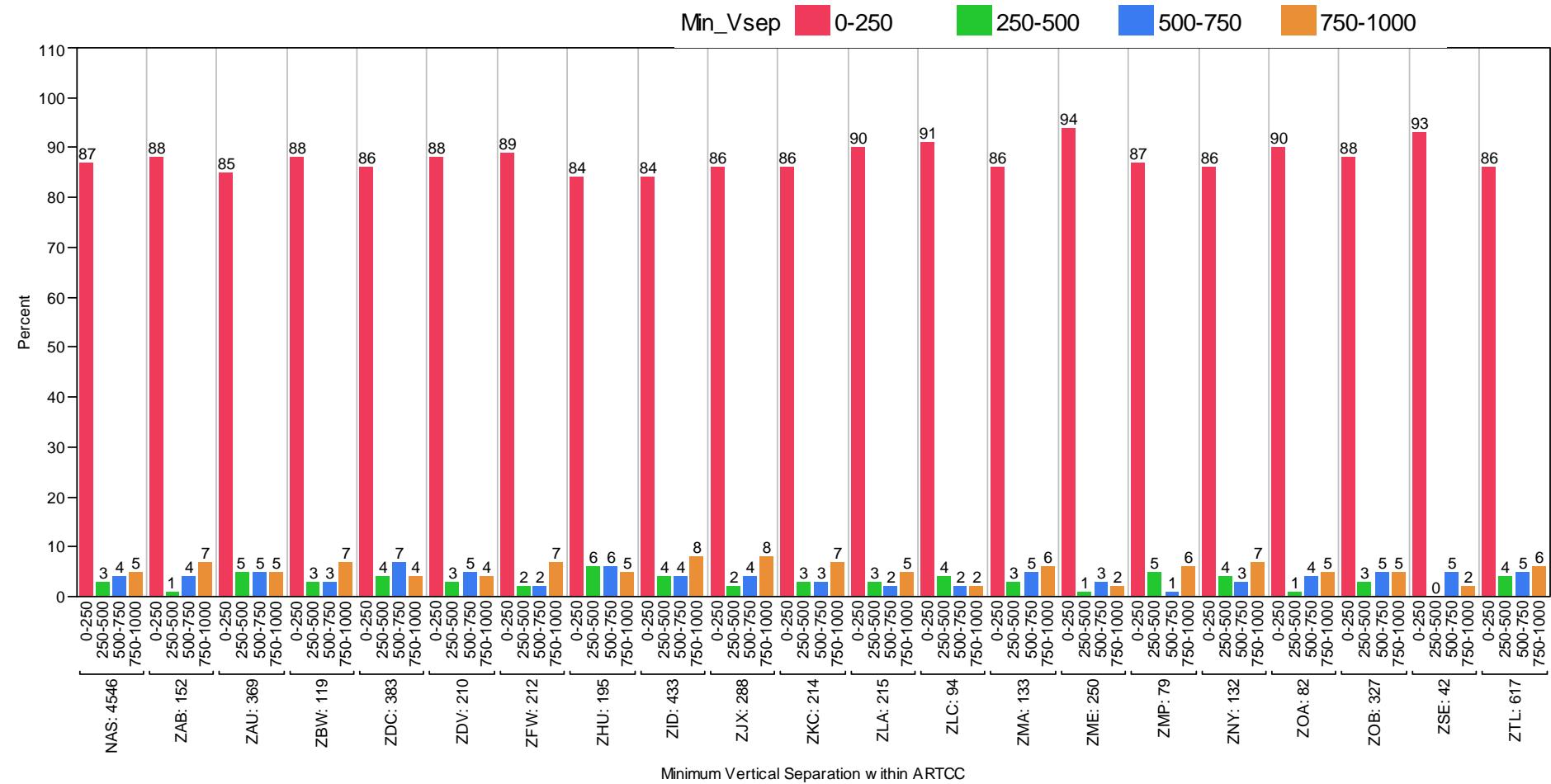
- Previous 2001 NAS study – 75% conflicts level
- European study of 2003 traffic – 18% conflicts level
- Chart above illustrates only 33% conflicts level
- Also large variation between ARTCCs

Results: Event Conflict Properties



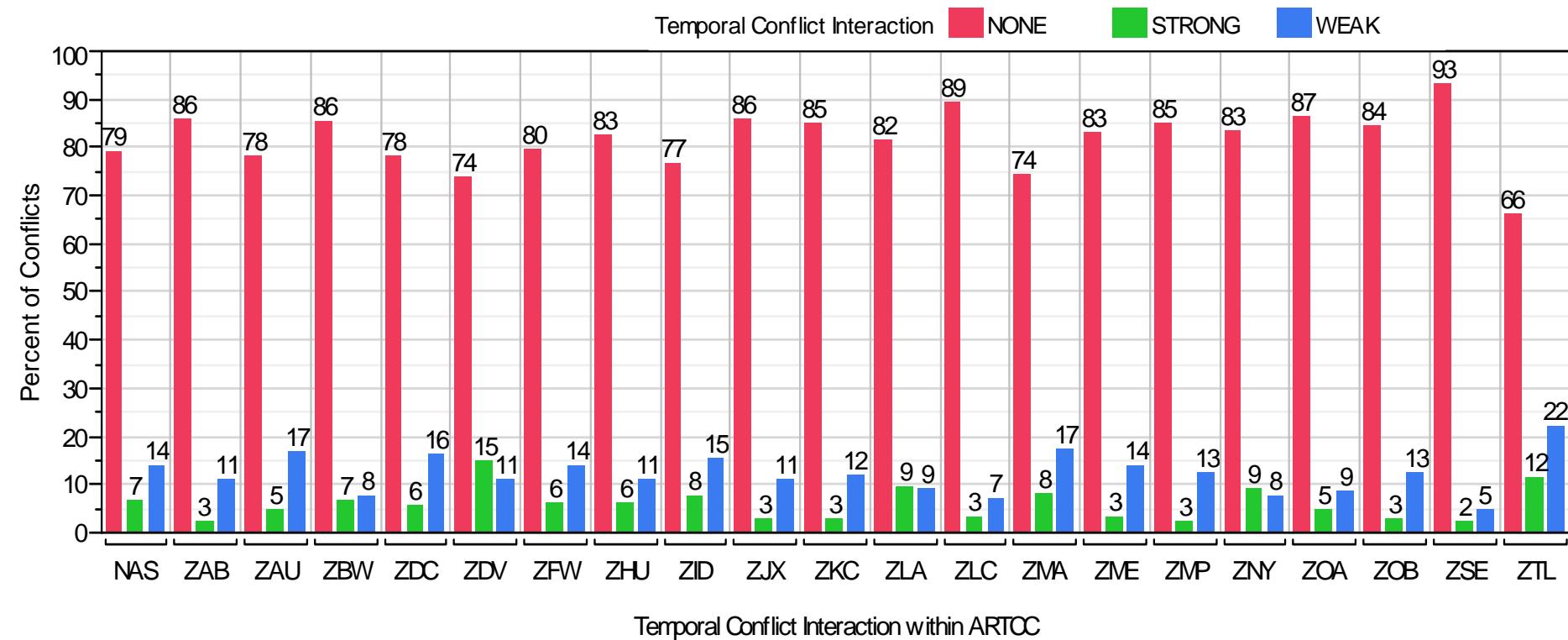
Thus, horizontal separations skewed left, meaning typically between 3-5 nm ~ 60% of conflicts

Results: Event Conflict Properties



Vertical minsep is opposite, 87% conflicts 0-250 ft

Results: Interaction Conflict Properties



- Conflict time relationship when one or both aircraft in common
- None indicates no time relationship; Strong indicates actual time overlap; Weak indicates not overlapping but near in time
- 2001 study 84%, 6%, 10% None, Strong, Weak – thus similar results!

Closing Remarks...

- **Comprehensive study completed**
 - Developed tools and analysis platforms
 - Partitioned by all 20 ARTCCs above FL180
 - Analyzed 5.5 peak traffic hours of data
- **Regional patterns exist**
 - Coastal regions concentrated conflicts, vertical phase and altitudes are different than middle of U.S.
 - Significant differences with legacy studies
- **Follow-up studies: more days, seasonal factors, etc.**
- **Detailed data posted to web:**
<http://acy.tc.faa.gov/cpat/docs/paperCpAiaaGnc2008/>

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Paper's Individual Web Site:
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